Compliments

Mr Wm R. Hutton

85 Broadway City

ARGUMENT

OF

CAPT. JAS. B. EADS

BEFORE THE

COMMITTEE ON COMMERCE

OF THE SENATE,

AND THE

COMMITTEE ON RIVERS AND HARBORS

OF THE HOUSE OF REPRESENTATIVES,

MAY 21 AND 22, 1884,

IN SUPPORT OF

SENATE BILL 1632 AND A LIKE BILL IN THE HOUSE,

TO PROVIDE FOR THE

IMPROVEMENT OF THE CHANNEL

BETWEEN

GALVESTON HARBOR AND THE GULF OF MEXICO.

WASHINGTON:
RUFUS H. DARBY, PRINTER.
1884.

ADDRESS.

Mr. Chairman and Gentlemen of the Committee:

Several months ago while in London I received a communication from the Mayor and Council, and a very large number of the most prominent citizens of Galveston, asking my opinion as to whether deep water could be secured there, what it would cost, and whether I would be willing to undertake the work. A number of times within the last few years I have been urged by prominent persons in Galveston to express my opinion as to the probable success or failure of the plans upon which the Government engineers are seeking to improve this harbor, but in every instance I declined to express my opinion on the subject. When, however, I received the communication to which I have referred I felt that it was my duty to speak frankly, which I did in a letter since published in this country, and which, perhaps, some of the members of the committee may have seen. In it I emphatically declared:

1st. That deep water could not be secured under the present plans of the United States engineer officers.

2d. That I was sure I would be able by works properly located and constructed, to secure a navigable channel through the outer and inner bars, thirty feet in depth; and

3d. That I would be willing to undertake the work upon terms then stated, the total price to be $7,750,000, payable in installments as various depths were secured. The payment of money by the Government to be in every case dependent upon channel depths obtained, and no money to be paid unless I fully complied with all obligations assumed by me.

My appearance here is at the urgent solicitation of the people of Galveston and that of the united Texas Congressional delegation, and I come the more willingly because I feel it due to myself that I should answer certain very unfair criticisms of my proposition, made by General Newton, Chief of Engineers, and Major Mansfield, the United States engineer officer in charge of the work, in their recent official reports upon the pending bill. I think I will be able to show you—

1st. That any appropriations to carry out the present plans will simply involve a waste of that much public money, because those plans are radically defective and never will accomplish the purposes designed; and

2d. That by proper plans deep water can be secured. I have no hesitation in declaring that I can, beyond all doubt, and within a comparatively short time, give to Galveston as good, if not a better, channel than that through the jetties at the mouth of the Mississippi.

An examination of the reports of the Chief of Engineers from 1874 to the present date shows, so far as I am able to discover, that no change had been authorized in the plans submitted by Major Howell ten years ago for the improvement of Galveston harbor, except in so far as relates to the method of constructing the works.

In submitting the survey and plan, Major Howell says: "The object of the survey, as stated in your letter of instructions, was to determine and estimate the cost of some plan calculated to give an eighteen-foot entrance to Galveston harbor." This plan was referred to a board of engineers composed of General Tower, General Wright, late chief of engineers, and General Newton, the present chief of the corps. General Humphreys in his report, (Report Sec. of War, vol. 2, part 1, 1874,) under the heading of "The Improvement of Galveston Harbor," says: "Captain Howell submitted a report upon the results of the survey he had been directed to make for the purpose of determining and estimating the cost of some plan of improvement calculated to give an eighteen-foot entrance to this harbor."

I desire to call attention to the fact that only an *eighteen-foot entrance* was contemplated by Major Howell's plan, and that no alteration has since been announced by which it can be claimed that it will produce a greater depth. General Newton says in his recent report upon Senate bill 1652, embodying my proposition, "The mode of improvement at Galveston has been reported upon by Boards of Engineers in 1874–'75–'76 and 1880. Two jetties on the south and north were recommended as necessary, and this view has since been held without a change in this office."

I am further justified in declaring that the present plan of improvement does not contemplate securing a channel of more than eighteen feet, from the following statement in General Newton's recent report on this bill, when taken in connection with the reports of the various boards of engineers to which he refers. General Newton says:

"The north and south jetties, placed according to the official plan, can, by an extension into deep water, and by the construction of auxiliary works, if needed, be made to develop all the depth of channel which the nature of the locality will admit."

In the face of the fact that these several boards have

reported upon this plan without altering it or recommending an alteration by which a greater depth than eighteen feet is to be secured, Colonel Mansfield has not hesitated to make the following statement in a report which he has submitted upon Senate bill 1652, which provides for a depth of thirty feet. He says:

"The Government is to commit itself to the payment of $7,750,000 during the next sixteen years for about what the Government can secure by continuing the present work during the next two years for $750,000."

General Newton, in his report upon the bill, likewise makes the following inaccurate statement:

"The case can be plainly stated as follows: Colonel Mansfield, with the expenditure of $750,000 and two seasons' work, will obtain an increase of depth exceeding two feet, and probably reaching five or six feet, while Mr. Eads and associates promise after a period of two years and eight months after the passage of the bill to gain two feet of depth for an expenditure upon the part of the Government of two million dollars."

He says "*after* a period of two years and eight months," which is precisely the reverse of what the bill declares. Instead of the word "*after*" the bill declares that I must secure at least two feet *before* two years and eight months, under penalty of forfeiting the privileges, &c., set forth in it.

The Mississippi jetty bill contained a similar clause with the same time for a forfeiture of the grant, but in one year from the date of the approval of the act, the Mattie Atwood, drawing thirteen feet of water, passed out through the uncompleted works, and although we had, as in the present bill, eight months in which to begin the works and two years thereafter in which to accomplish specified results, we commenced them in about three months and deepened the water five feet in nine months, and in two years and eight months after the approval of the law, we had secured a twenty-two foot channel, having deepened the bar fourteen feet.

It is important when comparing the estimate of cost for the completion of the works on the present plan, with those which I propose, to bear in mind that the former plan only contemplates a depth of eighteen feet at mean low tide, while my proposition is to secure at least thirty feet at mean high tide, or eleven feet greater depth.

At the time Major Howell's plan was approved by the board referred to, General Humphreys, then chief of engineers, General Wright, the last chief of engineers, and General Newton, the present chief of engineers, and Major Howell, were the most prominent and outspoken opposers of

the application of the jetty system at the mouth of the Mississippi River. The Galveston plan and the reports of the boards on it, and the arguments advanced by its members at that time, and subsequently, all bear testimony to the fact that these gentlemen entertained views directly contrary to the theories on which I based my expectations of success at the mouth of the Mississippi.

The late chief of engineers (General Wright) was the president of the civil and military commission of engineers to which was referred the question of applying jetties at the mouth of the Mississippi. He reported adversely to the jetties, and in favor of the Fort St. Philip Canal. Later on I shall have occasion to quote from the official reports of Generals Humphreys and Newton and Major Howell, regarding their ideas of the jetty system.

To enable the committee to form an intelligent judgment upon the merits of the Galveston plan, and to forecast the probable results which will attend its completion, it will be important to refer to the general principles or natural laws which control the action of flowing water and its power to transport sand and other sedimentary matter, so far as these laws are involved in the jetty system. To enable the committee also to fully comprehend the reasons which actuated these officers in recommending the Galveston plan, it will be necessary to quote from their official reports some of the ideas which they then entertained, so that the committee may see how completely their plan harmonizes with the errors which possessed their minds at that time.

If the natural laws referred to are clearly understood by the committee, it will have no difficulty in arriving at a correct judgment in the premises. The jetty system is a method of deepening and maintaining a channel across a shoal by such artificial works as shall compel the water flowing over the shoal to pass through a narrower channel. The principles involved in the system may be thus stated in brief:

1st. The current is caused by the fall of the water from a higher to a lower level, which fall is indicated by the slope or inclination of the surface of the water.

2d. The friction of the bed over which the water flows is the chief element or force opposed to the current.

3d. The force of the current will be increased by either increasing the slope of surface, or by increasing the volume of water passing through the channel, or by increasing both.

4th. The friction of the bed controls the velocity of the current just as the application of the brakes to a railway train, going down grade without the aid of the engine, regulates the velocity at which the train moves. The railway

brakes and the friction of the bed are to this extent identical in their effect.

5th. The friction increases just as the width of the bed increases. That is to say, if the bed of the channel be twice as great, the friction will be twice as great. It is important to remember the fact as we proceed, because friction is one of the very important elements that are totally ignored in planning the Galveston jetties, as will be presently seen.

6th. The power of water to transport sand increases with the square of the velocity of the water. That is to say, if the current be made twice as rapid, it will be able to transport four times as much sand.

Now if we consider these simple facts in their application to the plan now being executed at Galveston, it will be apparent that if the jetties, instead of being located twelve thousand feet apart, (2¼ miles,) were located, for instance, only four thousand feet apart, the friction retarding the flow of the water through them would only be one-third as great. Hence, with the same slope of surface from Galveston Bay to the sea, or from the sea to Galveston Bay, the current through them would be greatly accelerated. And as the transporting power of the water increases with its velocity, it would, with this reduced width of channel, be much greater, and it would more rapidly excavate and maintain a much deeper channel than could possibly be secured by the present design.

The reason why these jetties were located so widely apart is to be found in the fallacious arguments which the officers responsible for the plan advanced regarding the reformation of the bar. Major Howell, discussing in 1874 the application of jetties at the mouth of the Mississippi, declared that—"Jetties will have to be built further and further out, not annually, but steadily every day of each year to keep pace with the advance of the river deposit into the gulf, provided they are attempted," (at the mouth of the Mississippi.)

General Humphreys (Ex. Doc., No. 220, 43d Congress, 1st sess., April 15, 1874,) says, under the head of "South Pass:" "The mean width of the pass is 700 feet, but a less width for the jetties must be taken if a channel way of suitable width with a depth of 27 feet at low water is to be attained. Assuming 500 feet for this width, then as the width of this bar, where the annual accretion of 111 feet is made, is 3,000 feet, we shall, with jetties 500 feet apart, have an annual advance of 670 feet."

General Newton, in the same document, under date of April 4, 1874, (see report of Secretary of War, 1874, vol. 2, part 1, p. 883,) says:

"It is evident, that in proportion as the cross-section of discharge on the outer crest of the deposit or bar widens, its progress into the gulf will become slower, and on the other hand, if the cross-section be narrowed, the progress of the deposit will become more rapid. Whether the relative progress be in the simple inverse ratio of the width of discharge, or in some other, it is not important here to inquire. The essential fact, that as the width of the cross-section diminishes, the rate of progress of the bar into the Gulf must increase, is self-evident.

"Let us test by this rule the relative advances of the bars at the mouths of the Southwest Pass and South Pass, and of Pass a L'Outre, each mouth being supposed to be treated with the jetty system, and the width of cross-section at the end of the jetties, being that corresponding to the maintenance of the depths of 25 feet on the passes themselves.

	Southwest Pass.	Pass a'L'Outre.	South Pass.
Natural width of cross-section of discharge into the gulf	*Miles.* 2 5/8	*Miles.* 1 5/8	*Miles.* 1
Width between heads of jetties	3/4	4 2-300	1/8
Ratio between these	3	4	8
Present annual rate of progress of the bar	*Feet.* 338	*Feet.* 302	*Feet.* 280
Estimated annual rate of progress of the bars after completion of jetties	1,014	1,208	2,240

General Newton, in the above, undertakes to show that, under the influence of jetties at the mouth of South Pass, to produce only twenty-five feet depth of water, the advance of the bar would be at the rate of 2,240 feet per annum! As the jetties have maintained a thirty-foot depth of channel for nearly five years, during all of which time there has been no occasion to extend them a single foot, and as there has been no indication of bar advance to justify a belief that it will be necessary to extend them a single foot during the next hundred years, it must be evident that all these distinguished officers were greatly mistaken. If General Humphreys had been correct I should have had to extend the jetties by this time nearly three-quarters of a mile; if General Newton had been correct, I would have to be at work to-day on the jetty ends two miles and a half farther out, where the water is 160 feet deep; and if Major Howell had been correct, the jetties would be well on their way towards Cuba.

When the stubborn facts of 1884 at the mouth of the South Pass are compared with these declarations, comment becomes unnecessary.

That the entire board which approved Major Howell's plan, entertained the views expressed by these officers will be seen from the following qotation from their report to the Chief of Engineers:

Major Howell says, (report of Secretary of War, 1874, vol. 2, part 1, pp. 732–'3:) "The jetties are expected to act as training walls for the lower-ebb channel, while the upper will pass over them. They are calculated to give a depth on the outer bar of from 18 to 19 feet, and at the same time only confine and direct so much of the ebb and flood currents as may be useful, thus preventing a great advance of the bar gulfward, as might be expected were the jetties built up to the plane of mean low tide."

At page 737 of the same volume Messrs. Tower, Wright, and Newton say:

"The letter of instructions before referred to imposes the condition that an increased depth of water shall be 'permanently' secured. If taken literally this condition cannot, in the opinion of the board, be fulfilled by the present project, or by any other known method of improvement."

This opinion, regarding the impracticability of securing a *permanent* depth of channel, is based upon this mistaken theory of bar advance.

After submitting his estimate of the cost, Major Howell says:

"After construction, these jetties will, from time to time, require extension to keep pace with the extension of the bar gulfward The times and amounts of such extensions cannot be stated, but it is my opinion that the advance of the bar will not be rapid."

The quotations I have made from General Humphreys and General Newton's reports respecting South Pass show that, in their opinion, in proportion as the improved channel is narrowed by the jetties, the greater will be the rate of bar advance. As this would, in their judgment, be more rapid with a narrow channel, and as the whole plan at Galveston was purely experimental, the very moderate depth of 18 feet was taken as the maximum that should be secured to reduce to the lowest limits the enormous expense that was to be looked for in the extension of the jetties afterwards. General Humphreys stated that the annual extension of jetties at the Southwest Pass would cost a million dollars per annum. The depth of 18 feet was the least that the demands of commerce could be satisfied with at Galveston, and as this depth

was determined upon, it followed, by their arithmetical theory, that the magnificent width of $2\frac{1}{4}$ miles was necessary to be established between the two jetties to restrain the phantom of bar advance.

These gentlemen totally overlooked the fact that the friction through such a wide channel would neutralize the effect of the current, an increased force of which must be had to insure the deepening of the channel. Forgetful of the retarding effects of friction on such a channel, they then committed their crowning mistake of leaving enormous lateral outlets near the land, through each jetty, by which the current should be still more enfeebled.

Another equally important principle involved in the jetty system was likewise overlooked by them. I allude to the effect of wave action upon the sandy bottom of the shore of the sea. Neglecting the consideration of this important factor, it is simply impossible to permanently maintain between submerged jetties any increase of depth even if their works could produce it. It is necessary to explain wave action so that the committee will fully understand its bearing upon the question of bar advance, as well as the maintenance of the channel between the jetties.

The waves of the sea produce no continuously horizontal motion whatever in the water over which they are passing, unless the depth be so shallow that the crest of the wave when it sinks will feel the resistance of the bottom. When this occurs a motion of translation or horizontal motion, invariably toward the shore, is induced in the water. Of course, the higher the waves the greater will be the depth at which this horizontal movement will be produced. The waves of the Gulf of Mexico are not high enough to produce this effect sensibly in a greater depth than twenty-five or thirty feet. Waves result from the friction of the wind, and they increase in size in proportion to the "fetch" or distance they are driven under its influence. The fetch in the Gulf of Mexico is limited to about eight hundred miles, and the waves are not, therefore, excessively high. Large waves near the shore are always driven towards the shore, for the reason that a wind blowing off the land cannot create them of any considerable magnitude near it, and because the shallower the water in which the waves are travelling the slower will be their progress; hence, if the waves are moving under an impulse parallel to the shore they will be moving at right angles to that shore and the end of the wave nearest the land will move more slowly because it is in shallower depth. This will cause the waves to come obliquely upon the shore. Hence the horizontal or translatory motion of the water in-

duced by the waves is always towards the land. As they move onwards to the beach, this horizontal motion increases in velocity until under its impulse the water is driven far out on shore.

Under the influence of severe storms the transporting power in the gulf waves is limited to the depth of twenty-five or thirty feet, and increases in strength as they roll into the shallower water; therefore when they rush out upon the beach they are highly charged with sediment; a momentary pause ensues before the retreat of the wave occurs and during this pause the sand is dropped on the shore. As the return current starts from a state of rest it has less power to carry the sand down to the sea than the rapid current had to bring it out upon the shore. In addition to this the retreating current has less volume, because during the momentary pause before the ebb sets in, the volume of the water, which is one of the elements producing the current, becomes much less than it was when coming out on to the shore, much of it sinking into the beach, and, therefore, the return current, although induced by the steep slope, will be slower and incapable of transporting all of the sand back again.

In this way the sea waves are continually transporting sand shoreward on the sandy beaches of the sea, and where no lateral current exist these beaches continue to grow seaward.

The water which issues from any tidal basin such as that at Galveston or from any river, must struggle to reach the sea through the barricades of sand that are thus continually heaped up by the waves.

Now, as the influence of this action depends upon the height of the waves, it must follow that the deeper the mouth of the jetty channel is made, the less will be the ability of the waves to create a bar in front of that channel. I think it would be simply impossible that the waves of the Gulf of Mexico should disturb the sand in the bottom of the channel twenty-five or thirty feet deep at the end of the jetties. This opinion is based upon experience and observation at the jetties of the Mississippi River. Consequently, instead of there being a propriety in placing jetties two miles and a quarter a part at such a location as Galveston, through fear of an advance of the bar, it must be evident that they should be placed so as to create the deepest channel compatible with the safety of the jetties against being undermined, and with due regard to the economy of their maintenance. The closer together they are, within the limits of safety, the less will the friction of the bed retard the entry and exit of the water through them, the deeper will be channel produced by the current, and the earlier will be the relief afforded to com-

merce. The deeper the channel the less possible will be the reformation of the bar in front of it. If they be placed too close together, the channel will become so deep that the jetties themselves will be undermined, or the cost of maintenance will be increased.

It must be evident to any engineer who takes up the study of a problem like this, that these gentlemen entirely overlooked the effect of both friction and wave action in the location of their works, and were totally wrong in anticipating an advance of the bar; nor did they consider the effect of wave action in determining the height of their jetties. In a space of two and a quarter miles wide, and but from twelve to fourteen feet deep, with a bottom of quicksand, disturbed by every storm which sweeps across it from one side or the other, the wave action would be sufficiently energetic to level down and obliterate any channel which the current in calmer weather might be able to excavate; but it will be presently seen that the height to which they limit the jetties, must expose any channel excavated between them to serious interruption, if not obliteration, by the sands which would be transported from the outside of them into the jetty channel. They propose that only a portion of their jetties shall be built up to the level of mean low water, thereby leaving the tide to rise from one to four feet over the tops of these portions even where they are highest.

The jetty system is essentially a system of conservation of the water and not one of diffusion. But, as if this facility of overflow were not a sufficient violation of the fundamental principle underlying the jetty system, they actually leave into their plan enormous outlets by which the lateral escape of the water through each jetty near the land will be made. (See plan of works in Colonel Mansfield's report of 1880.)

What is known on the Mississippi River as the *outlet system* has undergone the most crucial scientific discussion and careful study during the last eight or ten years. It has been condemned by the Mississippi River Commission, who were directed by Congress to examine and report upon it, and it has been also rejected by the action of several Congressional committees as a system wholly wrong in principle where the deepening of a channel is to be sought. Although this decision was arrived at four or five years ago the experimental plan of the Galveston jetties has continued, and the flood-tides, whose volume should be retained in their outflow to deepen the chanel, are allowed to escape over the whole length of the submerged jetties.

Under the mistaken idea of facilitating the inflow of the tide, oblivious of the fact that, if it be made to flow through

one single channel of moderate width, it will have less friction to retard it, and will more easily fill the bay than if it be made to come in through three wide ones, they proposed two lateral channels near the land end of the jetties. The one through the south jetty, as shown on the plans published 1880, is a mile long; the one through the north jetty is ten thousand feet, and the one through the direct jetty channel is two and one-quarter miles, making a total width of over five miles. They seem to have wholly forgotten also that these lateral outlets will offer the readiest, shortest and easiest route for the escape of the ebb tide, which must do all of the excavation required to secure and maintain the improved channel. They evidently believed when planning these novel works that the water will flow in through these short routes to the bay, but will go out through one three times as long to deepen their channel. If we suppose the height of the water at the present outlet of Galveston Bay, between Fort Point and Bolivar Point, to be twelve inches beyond the level of the gulf beyond the bar, it will be seen that to reach this latter level through the jetties the water must travel about four and a half miles, which would give a slope of about two and a half inches per mile, whereas, through these great lateral outlets the water can reach the same level in a distance of a mile or two, by a fall more than two or three times as steep. It is, therefore, preposterous to suppose that the discharge of the bay will be made through the ends of the jetties and over the shallow part of the bar when it can be so much more easily discharged through and over the jetties. But aside from this great error, which ignores one of the most elementary principles of hydraulics, namely, that water will flow by lines of least resistance, it is absolutely necessary that the jetties to be successful should be built up so high as to prevent not simply the waste of water over them, but also the wave action bringing sand over their tops from the outside into the improved channel.

General Newton, when discussing in 1874 the application of jetties at the mouth of South Pass, said, (see report Secretary of War, 1874, vol. 2, part 1, p. 885 :)

"The longitudinal section of its bar and bed by its irregularities indicates very clearly that the shoaling process is going on throughout, and that the pass at the present time is hanging between the conditions of a live pass and a stagnant ditch, to the last of which results it must arrive if a revolution in the delta does not redeem it. And this most probable fate will be precipitated by applying the jetty system to its mouth."

In his official criticism of the bill which embodies my

proposition to produce thirty feet of water at Galveston, at the sole risk of myself and associates, and without pay if we do not succeed, this same officer says: "Should Congress be resolved to make a change in the administration of this work, at least it will be for the interest of the service to await the construction of the north jetty, and the observations of its effects which will lead to the possession of facts and data calculated to throw a needed light upon the amount necessary to be expended for obtaining a proper depth on the bar." When we examine the reports of these officers and read the the prediction of their chief regarding the South Pass of the Mississippi which, by his scientific reasoning was to be converted into a "stagnant ditch" by the application of jetties instead of being made by them, as it is, the grand highway of a nation's commerce, it cannot be wondered that he should utter this plea for "the interests of the service" and declare that they will be promoted by the possession of facts and data by which a needed light can be thrown upon the problem they have in hand. The want of this "needed light" in 1874 caused the present chief of engineers not only to oppose the application of the proper method of securing deep water for the great valley of the Mississippi, but also to sustain a hopeless plan to give eighteen feet of water at the chief shipping port of a territory larger than Great Britain. And now ten years after he recommends that the interests of Texas and the vast section tributary to Galveston be subordinate to the interests of "the service;" and in admitting the lack of this "needed light," he virtually admits what every citizen of Galveston well knows by this time, namely, that the plan to which they are clinging so tenaciously to-day is simply an experiment which, in ten years, has produced no substantial benefit whatever, and from which it is utterly hopeless to expect any in the future.

In comparing the cost of the jetties contemplated in Senate bill 1652, with those which were constructed at the mouth of the Mississippi River, for five and a quarter million dollars, it will be observed that the distance to deep water across the bar at Galveston is more than twice as great as it was to the same depth at the mouth of the Mississippi. In other words, the jetties at Galveston must be more than double the length of those at the mouth of the Mississippi. The cost of extending works out into the sea to twice the distance involves a much greater cost than would be at first supposed, because the further out from the shore the works extend, the more exposed they become, the heavier they have to be constructed, and the greater is the danger to the boats, apparatus, &c., required in their construction. In addition to the

length of jetties required, extensive works are needed to deepen the inner bar, to create a depth of thirty feet to the harbor of Galveston. These works will need to be quite as extensive and quite as expensive as those which were required at the head of the South Pass.

In comparing the amount of seven and three-quarter millions with the official estimates for the completion of the works at Galveston, it will be noted that these estimates do not include any works for the deepening of the inner bar. Upon this subject the board of 1874 says, (see report of Chief of Engineers, vol. 2, part 1, page 739:)

"As regards the works within the bay, designed by Captain Howell for the purpose mainly of increasing the width of the harbor of Galveston, and of improving the bar at its mouth, the board is of the opinion that nothing should be done till the question of the practicability of permanently improving the outer bar shall have been demonstrated, and it therefore expresses no opinion thereon."

The two jetties which are required at Galveston will have to be nearly nine miles long, and will have to extend out into much deeper water than those designed by Major Howell. In addition to this, as I have already stated, it is absolutely necessary that they be built up, not simply to high tide, but very considerably above it, to prevent the sand from being brought over into the jetty channel from the shoals on the outer sides of the jetties.

Colonel Mansfield reports that the south jetty is only built up to mean low tide, through a distance of about four and one-quarter miles. The plans for the north jetty show that it is to be built up no higher, and for a distance only about one mile. It is therefore unfair as well as idle to attempt to compare the cost of this system of low submerged jetties, from two to fourteen feet high, and not extending into deep water with those which must, to be successful, extend out into it, and be built to twice or three times the average height of the other, for the reason that the cost of both systems will be as the square of their heights, other things being equal, while the extensions into the deep water will increase in a much more rapid ratio. Besides the jetties must be capped with heavy concrete blocks or other substantial constructions to resist the force of the waves, whereas the jetty built at Galveston has no such force to withstand in its submerged condition.

In proportion as we build the jetties up to the surface of the water, this force of the waves becomes more and more powerful against them. It must be apparent, then, that a jetty to resist the violence of the waves, and stop them from

breaking over into the channel, must be vastly stronger than if they be built only up to the level of mean low tide. Hence it is idle to attempt to compare the cost of jetties properly built up to the necessary height and extending with that height from the land clear out to 30 feet water beyond the bar, with those which have been designed by the United States engineers for Galveston harbor. As the tide sometimes rises three or four feet above mean low tide the jetties will have to be built at least eight or nine feet higher than the one now completed by Colonel Mansfield.

The total cost of this jetty wrongly located, and of these insignificant proportions, has been one million and a half dollars, including the wrecked gabionade on the north side of the channel.

If the plan of the Government at Galveston possessed real merit, it is not at all likely that the immense territory which is to be relieved by deep water at that harbor would attain the relief sought within the next fifteen or twenty years, if the present system of appropriating money to carry on public works is persisted in, and it seems so hopelessly fastened upon the country, that there is no present appearance of its abandonment. It is not unlikely that if the method by which the mouth of the Mississippi River has been deepened had been placed in the hands of the United States engineers and appropriations for it had been doled out in the way in which they are voted from year to year, that the works would scarcely be completed to-day, whereas the commerce of the Mississippi valley obtained its relief about seven years ago, at which time the depth through the jetties was sufficient to admit at least 90 or 95 per cent. of the commercial tonnage of the world, while for the last five years the depth has been amply sufficient for the largest steamers afloat.

By the proposition which I make it must be evident that it will be to the interest of myself and my associates to secure at the very earliest possible date the greatest depth of water which we propose to secure, and it is needless to say before this intelligent committee that the producers in the territory which is tributary to Galveston must annually save a sum far greater than that which it is proposed shall be paid for the entire work.